

I – Problem Statement Title (EQ 089)

Rapid Construction of Bridge Piers with Improved Seismic Performance

II – Research Problem Description

Question: Bridge construction is increasingly required near existing highways and in the presence of heavy traffic. The construction disrupts traffic, and as a result it is essential to complete the construction as quickly as possible to minimize the traffic delays and disruption. Despite the need for rapid construction, the bridge must be economical and provide good seismic performance.

Concrete filled tubes (CFT) for bridge piers are a promising method for solving this problem. The steel tube is prefabricated away from the construction site, and it is quickly erected at the job site with a relatively light crane. The footing can be a spread footing or a pile cap as used for reinforced concrete pier construction. Concrete fill for the tube can be quickly placed within the tube to develop the full strength and stiffness of the bridge pier. Self-consolidating concrete can be used and no vibration of the concrete is required. The steel tube serves as formwork, shear and flexural reinforcement and confining steel for the concrete. The concrete fill can be placed very quickly because there is no interference due to reinforcing bars. Construction time is minimized because there is no time needed for placement of reinforcement and building formwork. Past work has shown that the CFT is a very efficient structural element, because the reinforcement is provided by the steel tube and is at the optimum location. As a result, CFT bridge piers can be of significantly smaller diameter than precast or reinforced concrete bridge piers. This results in less material, lighter weight and smaller seismic design forces. At the same time, CFT can provide excellent ductility and inelastic performance with large inelastic deformation capacity. The pier cap can be constructed as a reinforced concrete element, but steel or precast concrete pier caps can also be used for very rapid field construction. Steel pier caps are more costly, but they have been used in Japan for very rapid construction during recovery from the Kobe Earthquake. It is anticipated that the proposed connection can also be adapted to a precast concrete pier cap, but additional testing may be required for that option.

It should be emphasized that the concrete filled steel tubes discussed here are composite members that are significantly stiffer, stronger and different from the steel jackets commonly used for seismic retrofit of bridge piers.

III – Objective

Roadmap Outcome: Dual Outcome of **Outcome #4 - Problem 4** "Optimized New and/or Existing Materials, Systems and Components for Bridges and Highway Structures" and **Outcome #3 - Problem 1** "Reduced Impact of Structure Construction and Maintenance Activities on the Traveling Public"

The research will develop a new and economical method for rapid construction of bridge piers. To fully develop this structural system, additional tests are needed on large-scale CFT elements to formally develop the design procedure for the CFT pier and its connections to the foundation and the pier cap. It is proposed that this work will build on current ongoing research for at the University of Washington. This connection employs a thin, slender, high strength steel tube with light flanges or annular rings used to form the

foundation connection. No internal reinforcement is required in the CFT pier or the connection. Normal rebar is used in the foundation and the pier cap.

IV – Background

The basic problem and research topic is described in Section II. The focus of the proposed research will be large scale testing of CFT piers and their connections. Nonlinear finite element must also be performed to supplement the test results and fully develop a design procedure for the system. The issue of corrosion resistance of the exposed steel will also be addressed through details to eliminate moisture retention, galvanization, and protective coatings.

V – Statement of Urgency, Benefits, and Expected Return on Investment

The research is critical to the development of the proposed system for rapid construction and economical and efficient bridge piers. The system will significantly reduce the construction time required for bridge piers and benefit CALTRANS in constructing bridges in areas with heavy traffic. In addition, work by Gaines (2000) showed that CFT bridge piers can reduce the material required for pier construction by approximately 15%, and this should result in further cost savings in future bridge construction.

VI – Related Research

- Mark Gaines (2000) has performed past research evaluating the economic benefits of using CFTs for bridge piers.
- Researchers at the University of Washington have developed an economical connection between a concrete filled steel tubes and foundations which can be quickly constructed and requires not additional reinforcement. This connection has been tested under severe cyclic with moderate sized steel tubes ($F_y = 70$ ksi, 20" diameter and d/t ratio of 80). The tests show that connection can provide good ductility.
- Tests are currently underway at the University of Washington evaluating the bending resistance and shear transfer between the steel and concrete.
- Initial work at the University of Washington has examined possible details for connecting the CFT pier to precast pier caps and for methods of corrosion protection.

VII – Deployment Potential

It is envisioned that bridge engineers for bridge design can immediately use this research as a final product.